

# Soil Survey of Warren County.

By E. J. GRIMES of the Indiana Department of Geology and  
E. H. STEVENS of the U. S. Bureau of Soils.

## DESCRIPTION OF AREA.

Warren County is situated in the western part of Indiana a little north of the center on the western boundary of the State. It is the fourth county south of Lake Michigan. It is bounded on the north by Benton County, on the east by Tippecanoe County, on the southeast by the Wabash River, which separates it from Fountain County, and on the west by Vermillion County, Illinois, and a small part of Vermillion County, Indiana. The county is somewhat triangular in shape, with the northeastern and southwestern part of the triangle truncated. The area is approximately 364 square miles, or 232,960 acres.

The county is divided into three distinct physiographic regions: (1) The river flood plain and terraces; (2) an undulating to rolling belt of timbered land; (3) the level to undulating prairie. The maximum width of the first division is about two and a half miles. It is continuous along the Wabash, but narrows down rapidly eastward from Independence. The river flood plain proper is relatively narrow for a stream of its volume, the average width being about one-fourth mile. The bottoms are usually bordered by broad, level benches or massive gravel terraces that rise from 25 to 75 feet above low water in the river. The best defined terraces of this division are the "Barrens" southwest of Williamsport, the terrace east of Kickapoo, and "Mound Prairie" on the southern boundary of the county. The second division, comprising the area fronting the Wabash River, has a somewhat broken surface. The larger streams and their tributaries on approaching the Wabash have deeply dissected the plain, and often acquire steep or precipitous valleys, sometimes walled in by perpendicular bluffs of sandstone. Some of these bluffs, as well as the Wabash valley escarpment are from 80 to 150 feet in height. This area of broken land extends along Pine Creek nearly to the northern boundary and is broadest in Liberty Township.

An area of pronounced relief comprising about 15 square

miles occurs along the lower course of Possum Run. It is characterized by numerous abrupt slopes and deep ravines. A similar topography prevails along the lower course of Redwood, Little Pine, Mud Pine and Kickapoo creeks. This division extends back from the river to an average distance of five miles.

The third division embraces the Grand Prairie. It occupies the western and northern three-fourths of the county. In general it may be said to be a gently undulating prairie, but varies from nearly level to gently rolling. There are numerous broad areas with but little or no relief except near the streams. Such topography prevails in the extreme southwest portion of the area, around Pence and east of Pine Village. The dominant, gently undulating surface of the prairie is broken only occasionally by morainic ridges or long sloping-like elevations. The most prominent of these moraines is known as "Blue Ridge" in Prairie Township. It extends in an easterly and westerly direction for four or five miles. The south side stands in clear relief while the north declines almost imperceptibly to the average surface level. The prairie as viewed from one of these elevations presents an undulating or billowy surface stretching away in all directions. Timber growth—*islandlike*—dot here and there its surface, and substantial farmhouses and barns are seen on every side, amid the fields of waving corn and oats. There are belts of rolling prairie. This topography is to be found more often where the prairie merges into the timber. An area north and west of West Lebanon, and northwest of Pine Village, has a decided relief. The long easy slopes that characterize this division are never too steep to interfere with cultivation. The average level of prairie above the river bed is about 175 feet.

Warren County is drained directly into the Wabash River, that flows in a southwesterly direction along the southeastern boundary. The course changes to a south direction at Covington. The river from Attica south occupies its preglacial channel, while above Independence for a few miles it seems to have a recent channel with bed and rarely banks of rock. The canal survey shows a fall of 19 feet from Lafayette to Attica, a distance of 25 miles; from Attica to Covington, 17 feet, a distance of 20 miles.

The principal drainage outlets on the north and east are Little Pine and Kickapoo. The lower courses of these creeks are flanked with bold bluffs of sandstone and gravel. Big Pine Creek enters the county near Pine Village and flows southwest to a point below Rainsville where it is joined at the south bend southward by Mud

Pine. It enters the Wabash at Attica. The valley is deep and tortuous, being 75 to 150 feet below the average surface level. From Rainsville to the junction, Pine Creek has carved a channel in sand rock. The generally broad bottoms and terraces together with the high bluff lines suggest that at one time this stream was an important drainage way.

Redwood, Rock and Fall creeks drain the central and southeast portions. Possum Run rises in the prairie north of Marshfield and flows south to join the Wabash at the great bend. At the headwaters it is a superficial stream, but farther south it is skirted by bold till bluffs. The north fork of Spring Creek flows south through a corner of Vermillion County. The hilly or rolling uplands adjoining the above streams include but very little untillable ground. The steep slopes break with remarkable quickness into the level plain. Frequently the slopes are cultivated to the very brink of the slope.

Prairie and Jordan townships are drained by Jordan Creek, a tributary of the Vermillion River in Illinois. The upper branches of this stream are surface streams with artificial channels that usually represent the former ill-defined and obstructed channels artificially enlarged and straightened by dredging.

In the first settlement of the county, much of the prairie was too wet for cultivation, and a number of marshes which had not reached the state of "wet prairie" were scattered at intervals within its bounds. To properly drain these water-logged areas was for years the chief problem of the farmers. This has been effected by the construction of a great system of surface and tile ditches that ramify through every portion of the prairie.

The elevations above sea level in feet of the different points, taken from railroad surveys, are as follows: Williamsport, 668; West Lebanon, 700; Marshfield, 706; State Line, 730; Pence, 700; Judyville, 771; Hedrick, 709; Pine Village, 702; Winthrop, 677; Kickapoo, 546, and Mound City, 628.

In 1824 a great many settlers had located in this region, largely in Warren Township. They were attracted by the fertile valleys and excellent pasture land on the adjoining slope. Here they were free from the pestilential ague. The county lines were located and the county organized January 19, 1827. Williamsport was selected as the county seat the same year. The early immigrants came largely up the Wabash from Southern Indiana, Kentucky and Ohio. The proximity of Indians somewhat retarded the advance of settlement.

The picturesque hills and chasms of Pine Creek had been for a century the favorite home of the Weas and Kickapoos. Independence, the oldest town in the county, was a trading point with the Indians as early as 1811. The first conveyance of land was recorded in January, 1828. The development of the area was burdened by the lack of transportation facilities. The only market was to the south; this was reached by the lengthy and perilous journey to New Orleans. The nearest grist mill was at Terre Haute. Lafayette, Chicago and Cincinnati were the markets for the early farmers. The advent of the Wabash Railroad in 1856 gave an outlet for the county's produce, and stimulated development.

The railroad facilities of the county are ample. Two north and south lines, the C. & E. I. and C. & Ind. Southern give direct connections with Chicago, about 100 miles north. The Wabash and the Peoria Division of the Big Four crosses the county east and west. A branch of the Illinois Central Railway enters the county from the west and meets the Wabash at West Lebanon. A branch of the main line of the C. & E. I. in Illinois terminates at Judyville.

The county has a total of 366 miles of improved roads. They are surfaced mainly with gravel. There is yet an inexhaustible supply of this road metal. Although the county is making a substantial progress toward a permanent system of good roads, there is yet an urgent need for a few roads in certain sections of the prairie not now open to travel.

The area is in a very prosperous condition. The improvements are of the best type. Well built farmhouses, large barns, good out-buildings and labor saving machinery are the rule. The fences, particularly on the prairie, are not much good. The land waste from osage orange fences is immense. Telephones and rural mail routes reach all parts of the county. Most of the farmers own high power motor cars.

The small country school is still maintained. There is an apparent need for a number of substantial brick schoolhouses conveniently located and equipped with modern conveniences.

Warren County is essentially an area of large holdings. The best farms in the county today, the farms that represent the substantially prosperous end of the business, are those that average at least 100 acres or more. There are several estates that exceed 1,000 acres. Consequently it is sparsely settled as compared with other sections of central Indiana.



According to the census reports the population has steadily decreased. The statistics are as follows: 1870, 10,204; 1880, 11,497; 1890, 10,955; 1900, 11,371; 1910, 10,899 inhabitants. The occupations are wholly agricultural. Some coal is mined, but only for local use. The future of the county will lie in the improvement and intensive development of its fertile soils.

Williamsport, the county seat, is a modern resident town of about 1,200 people, located on the west bluff of the Wabash River. It is not conveniently connected with most parts of the county.

West Lebanon and Pine Village are the only two remaining incorporated towns, with a population of 642 and 352 respectively. State Line and Independence are the next largest points. Kramer is the site of Mudlavia, a popular health resort. Pence, Tab, Hedrick, Marshfield, Foster and Judyville are small villages and shipping points for the prairie farmers.

There are eighteen railroad stops and as many elevators within the county. Danville, Lafayette, Attica and Covington are business centers for most of the farmers.

#### CLIMATE.

The climate of Warren County is characterized by wide variations in temperature and rainfall. Sudden changes of temperature are frequent. It is difficult to forecast the weather one day in advance. Periods of drought or years of too little rainfall for the requirements of corn and grass are frequent, and have been especially numerous in past five years. In all of these respects it resembles the climate of the general region.

The natural physiographic regions of the county are fairly well defined by climatic features. The prairie belt is marked by wider variations in temperature and smaller total amount of rainfall than the timbered portions. The proximity of the Wabash Valley tends to equalize the extremes of the eastern portions. It is popularly known that the storms follow the course of the river, and are more numerous than farther inland. The prevailing westerlies pass over the prairie without much deflection.

The following tables show the normal monthly, seasonal, annual temperature and precipitation at Lafayette, Indiana, and Danville, Illinois. The former records are representative of the Wabash Valley portion of the county, while the latter data is applicable to the prairie belt.

NORMAL MONTHLY, SEASONAL AND ANNUAL TEMPERATURE AND PRECIPITATION AT LAFAYETTE, TIPPECANOE COUNTY, INDIANA.

MONTH.	TEMPERATURE.			PRECIPITATION.			
	Mean.	Absolute Maxi-mum.	Absolute Mini-mum.	Mean.	Total Amount for Driest Year.	Total Amount for Wettest Year.	Snow Average Depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December.....	29.7	69	—17	2.59	1.95	5.84	3.5
January.....	25.3	70	—33	2.47	1.18	0.40	7.0
February.....	26.9	69	—26	2.75	2.94	5.78	6.3
Winter.....	27.3			7.81	6.07	12.02	16.8
March.....	37.6	83	—5	3.20	1.41	3.30	4.4
April.....	50.5	89	10	3.27	2.94	2.25	0.4
May.....	61.5	97	25	4.40	2.11	3.82	Trace.
Spring.....	49.9			10.87	6.46	9.37	4.8
June.....	70.7	100	33	4.43	1.97	7.16	0.0
July.....	74.6	105	42	3.77	0.88	2.05	0.0
August.....	72.6	102	39	3.23	0.47	3.08	0.0
Summer.....	72.6			11.43	3.32	12.29	0.0
September.....	66.1	101	29	2.77	3.02	4.20	0.0
October.....	53.3	92	16	2.35	1.62	4.42	Trace.
November.....	39.5	95	—1	3.06	3.72	6.49	1.2
Fall.....	53.0			8.18	8.36	15.11	1.2
Year.....	50.7	105	—33	38.29	26.21	48.79	22.8

Average date of first killing frost in fall, October 5; last in spring, April 26. Earliest date of killing frost in fall, September 14; latest in spring, May 27.

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION AT DANVILLE, VERMILION COUNTY, ILLINOIS.

MONTH.	TEMPERATURE.	PRECIPITATION.
	Mean. °F.	Mean. Inches.
December .....	30.5	1.99
January .....	26.5	2.92
February .....	27.1	1.75
Winter .....	28.0	6.66
March .....	39.6	3.54
April .....	52.0	2.78
May .....	64.8	3.55
Spring .....	52.1	9.67
June .....	72.5	2.82
July .....	76.6	2.96
August .....	74.0	2.91
Summer .....	74.4	8.69

MONTH.	TEMPERATURE.	PRECIPITATION.
	<i>Mean.</i> °F.	<i>Mean.</i> Inches.
September .....	67.8	3.55
October .....	55.1	2.55
November .....	40.6	3.25
<hr/>		
Fall .....	54.5	9.15
Year .....	52.3	34.17

It appears from the foregoing table that the mean annual precipitation is about 38 inches. The greatest amount occurs in months of May, June and July, nearly four inches each, and the lowest amount in the winter months. The total amount of rainfall even in the driest years is sufficient for all crops grown if proper cultural methods are employed on the different types to conserve it.

The snowfall is quite variable from year to year, but the average is 22.8 inches. It is generally sufficient to protect the winter wheat, rye and clover seedings.

From the Weather Bureau records it is ascertained that the average date of the last killing frost in spring is April 26th and the first in fall is October 5th, giving an average growing season of about 160 days. The records give the date of the latest killing frost in spring as May 27th, and the earliest in fall as September 14th.

The springs are oftentimes premature. The vegetation gets well started and is afterward injured by a severe frost or freeze. This is particularly damaging to the peach and apple crops. May and October are the balmiest months of the year, July and August the warmest, and January and February the coldest.

## AGRICULTURE.

Warren County comprises large areas of productive, well drained soils, which are susceptible to easy cultivation, and have endured continuous cropping remarkably well. The soils are still comparatively fertile and the crops produced in favorable years are yet large, but sufficient evidence is at hand to show that profitable yields of certain crops are not being obtained because of the deficiency of certain necessary elements, or because of the lack of proper physical conditions in the soil. Maximum crops may be obtained indefinitely if proper methods of farming are instituted at once. The decreasing yields of late years clearly show that it is now time for the farmers and landowners to make their greatest

effort to maintain the fertility and increase the productivity of their soils.

Farming operations were begun in this county about 1824 in Warren Township along the Wabash Valley. The rich soils of the bottoms and the good pasture land on the adjoining slopes and the freedom from malarial fever, together with the transportation facilities afforded by the river, caused the early settlers to select such sites. The water-logged areas of the prairie were ignored by the early farmers and their descendants in their search for well drained lands with timber for fuel and constructive purposes. It was then supposed that they would never be cultivated. As the settlers gradually pushed westward these areas were gradually taken up. The first part of the prairie section to be reclaimed was the better drained portions around West Lebanon and Marshfield. In the beginning the prairie lands were utilized by the men in the timber section for grazing purposes. Cattle feeding became an extensive industry of the early prairie farmer. The native prairie grasses were cut and used for hay, while corn was brought from a distance. Thirty years ago the prairie sod was unbroken. About 1882 tile drainage was undertaken and extensive systems of open and underground drains have since been completed, until today nearly all the black land has been freed of surface water and the areas thus reclaimed are the source of the enormous wealth of the county. The value of these lands may be seen from the assessed valuation of the county, which in 1914 was \$13,300,000; that of Prairie Township alone is \$1,951,510.

The crops grown are those characteristic of the corn belt—corn, oats, clover and wheat ranking in acreage in the order named. The cultural methods apply almost entirely to grain farming. Corn and oats are grown almost exclusively on the prairie farms. Little or no wheat is grown on the Carrington or Clyde soil. The small clover acreage has rapidly declined. The general trend of agriculture may be seen from the statistics of the U. S. Census tabulated below.

#### U. S. CENSUS.

	<i>Corn.</i>		<i>Oats.</i>		<i>Wheat.</i>		<i>Hay.</i>	
	Acreage.	Yield.	Acreage.	Yield.	Acreage.	Yield.	Acreage.	Yield.
1880.....	62,952	2,134,441	10,587	355,666	15,862	363,651	13,043	14,527
1890.....	54,613	1,740,244	25,285	886,023	12,695	177,851	19,323	23,689
1900.....	78,667	3,792,210	36,195	1,495,400	8,189	70,430	14,529	16,509
1910.....	75,789	3,250,565	48,071	1,664,179	7,973	153,023	12,196	14,218

Corn is the chief crop. All problems of soil management are planned in relation to the production of this crop, and will continue to be thus on account of the high prices offered for this grain and its adaptability to most of the types of soil in the region. The highest yields are obtained on the Clyde and Genesee soils, which produce nearly twice the amount of the Miami soils. Corn frequently goes less than 40 bushels per acre, but average yields of 70 bushels are not uncommon. The present practices in the cultivation of corn conform closely with the methods generally used throughout the prairie section of the corn belt. The land is fall plowed and the following spring the bed is stirred, leveled and pulverized with harrows. Most of the crop is planted with the check drill and cultivated both ways. The land is usually harrowed when the corn is coming through the ground or while yet young. The roller then finishes pulverization. Three to five shallow cultivations are given as a rule and crop laid by about the first or middle of July. Most of the corn is husked by hand, shelled and hauled to the elevators, but in late years a larger percentage of corn is being cut for ensilage, especially on the Miami farms. The number of silos is increasing rapidly, and is frequently the determining factor between profit and loss in cattle feeding. The planting of cow-peas or soy-beans in the corn at the last cultivation, to be cut with the corn for ensilage, is to be recommended. The limited quantity of barnyard manure on hand is applied to the land intended for corn. Some commercial fertilizers are applied to the corn on the gray soils. The applications are usually too small and not properly balanced. The corn produced on the Miami soils grades better than that grown on the dark types. The prairie corn oftentimes fails to mature properly, and the cob averages large. Strains of Reed's Yellow Dent and Leaming constitute the main varieties grown. Seed selection is not generally practiced. The seed is brought from Illinois. More attention should be given to the improvement of corn by breeding up varieties on the different soil types. Good seed corn is available from growers in the same latitude in Indiana and would be preferable to that from other States. As to cultivation, the prevailing practices are good. Deep or shallow cultivation depends upon seasonal conditions, but in general the first cultivation should be as deep as possible. It should go down almost as deep as the furrow that has been turned. This will restore the connection of the soil and subsoil. The remaining 3-4 cultivation should be as shallow as possible. A dry dust mulch should be maintained at all times.



Oats are generally sown broadcast over the corn, or oat stubble land and harrowed under in the early spring. The acreage of this crop has steadily increased until on some of the prairie farms the acreage is almost equally divided between corn and oats. An average yield over a period of years will be about 30 bushels. Oats are cut and left shocked in the fields until the thresher outfit arrives, and thus are frequently damaged by exposure. Most of the grain is shipped out of the county. The straw is baled and sold. The seed oats are grown locally. At present it does not seem profitable to breed up a local strain, but the seed should be secured about every three or five years from more northern latitudes. Smut reduces the yield of oats at least 3-10 per cent. All seed oats should be treated with formalin before planting. Fertilizer tests by the Indiana Station show that the use of commercial fertilizers on oats is uncertain, and positively unprofitable where nitrogen is used in the formula. Two hundred to three hundred pounds of 6-8-4 mixture might prove successful on the Miami soils.

Winter wheat production has gradually declined and, much like oats, is grown mostly for its value as a cover and nurse crop for clover and timothy. But little wheat is grown on the prairie on account of the winter killing by heaving. Some of the farmers prepare the land for wheat by ploughing, while others drill the wheat in standing corn; when the latter is done the surface should be kept clean and mellow. By cutting the corn and removing from the fields, and harrowing before drilling would insure a better stand. Wheat responds better to commercial fertilizers than either corn or oats, and there are but few farms on which fertilizers of proper composition will not give a profitable yield when applied in connection with good farm practice. The Indiana Station recommends for general use about two hundred to three hundred pounds per acre of a fertilizer containing about 2 per cent. nitrogen, 10-12 per cent. phosphoric acid, and 4-6 per cent. of potash, drilled at the time of seeding. The nitrogen may be omitted on soils well supplied with organic matter. Where commercial nitrogen is used in the rotation it should always be applied to the wheat crop. On most of the farms wheat follows corn to better advantage in the corn, wheat and clover rotation. It does unusually well after soybeans or cow-peas; hence a rotation of corn, soybeans, wheat or oats and clover. Better drainage should be established on most soils. Winter killing is a sign of poor drainage. The hardy Russian types, particularly the Turkey Red strains, are best for the prairie regions. The last week in September is the best time, as an

average, for seeding. The seed should be properly selected and graded. If attention were given to these details, and the information of the Experiment Station utilized, there seems to be no reason why the average yields could not be doubled and the profits enlarged from this useful crop.

The problem of securing a stand of clover within the last five years has been the most troublesome one confronting the farmers of Warren County. As an average it fails about three years out of five. The last two or three summers have been very dry and hot in this county so that when the nurse crop is removed the young clover burns out. This is usually induced by attempting to get a full crop of grain that draws too heavily on the available moisture supply. Other failures are due to acid soils, low germinating vitality, and failure to get seed properly covered. It appears that when land begins to decline in production of clover it is a sign that it is going to decline in the production of other crops as well. Under the above conditions it must cease to be included in the rotations and a substitute found for the short rotations. At present when the clover fails the farmers plow it up and follow with a cereal; as a consequence much of the land is suffering an enormous loss.

Doubtless a high percentage of the poor stands is due to the acidity of the surface soil; this is especially true on the Miami and lighter phases of the Carrington soils. One to four tons of ground limestone per acre will correct this condition and after it has been neutralized one-half to two tons once in the rotation should prove ample to prevent it from again becoming acid. Where clover is seeded in wheat or oats the stubble should be left as high as possible and the shocked grain removed as soon as possible after cutting. About one-third the usual amount of grain seed should be used and in some cases cut for hay before the heat of the season.

Numerous small plats of alfalfa were seen throughout the county. The acreage is increasing and giving profitable returns. But it deserves far more attention. Applications of lime are found necessary on most soils, but barnyard manure is frequently the determining factor of success. The average upland and sometimes the terrace soils lack proper physical as well as chemical condition. They need an addition of some substance that will increase the moisture holding capacity and will improve drainage by opening up the upper subsoil layers. Ten to fifteen tons of barnyard manure will serve for this purpose, and should be applied sometime before seeding. Top dressing in late fall or early spring where good stands have been obtained are very beneficial. Alfalfa can be

profitably produced on all the upland soils that are well drained, if they be thoroughly limed and inoculated.

Only a few tracts of cow-peas and soy-beans were observed in the survey. Both of these crops are well adapted to soil and climatic conditions of the area. They are more resistant to heat and drought than clover or alfalfa. This feature alone recommends them for the Fox and Sioux types. They gather nitrogen from the air and store it in their roots, thereby improving the soil in which they grow. They may be grown on a soil too acid for clover or alfalfa. They rank with linseed and cottonseed meal as a concentrated feed for cattle and hogs. They may be substituted as a catch crop for clover when the latter kills out. Cow-peas can be cut for hay or used for pasture, while the soy-beans could be threshed and the vines returned to the land either directly or as manure.

Sweet clover can doubtless be used to advantage on a number of soils, the Fox, Shelby and prairie types, when clover fails. It should be drilled in the oats at the time of seeding at rate of 12 pounds of hulled seed per acre. The nurse crop does not shade it out and the sun does not kill it when the oats are removed. The extensive root system is beneficial in many ways. Only a single field was seen, but it grows spontaneously everywhere.

There are a few principles of soil improvement applicable to all types of soil, in the use of the crops common to the region. In the first place the physical conditions of the soil with respect to the moisture content should be carefully maintained near the best as possible. This is dependent upon drainage and cultivation,—the most important factors in all farming operations. The second step is the proper rotation of crops. A legume should be included at least once in the 3-4 year rotation.

The next factor is the maintenance and increase of the organic matter and nitrogen content of the soil. The materials for this purpose are barnyard manure, crop residues and green manures. In conjunction with humus would be the use of ground limestone to neutralize the acidity present. The last operation will be the use of phosphatic fertilizers. According to the best evidence of the Purdue records, the phosphorus can be most profitably applied in the soluble forms, at least so by the renter. Five hundred pounds of acid phosphate once in the rotation should be sufficient. As the mechanical condition of the soil is improved the almost inexhaustible supply of potash present will become available.

The soil of Warren County is deep, averaging about 18 inches,

and for this reason subsoiling will never be practicable, but the use of deep tilling machines is to be strongly recommended on several types of land.

Stock raising and feeding has been considered unprofitable in the last few years. Cattle is imported from Chicago and fattened for the markets. This industry has received most attention in the vicinity of Judyville and Green Hill. But on account of the high priced lands there has been a tendency to plow up the pastures and grow more corn. Most farms should include sufficient livestock so that the rougher portions of their farms may be utilized, to help maintain fertility, to utilize the waste products of the farms, and to consume a part of the enormous quantities of grain produced. Dairying has received no attention. Hogs are best paying animals, and most of the corn consumed in the area is fed to them.

According to the census, the number of renters has rapidly increased in Warren County. In 1910, 41.6 per cent. of the farmers were renters. In the prairie sections, no less than 75 per cent. are tenants, renting on the share basis, the landlord demanding one-half the grain delivered at the elevators, the tenant furnishing everything. In most cases, pasture privileges are extra; some even exact a cash payment for the use of houses and other outbuildings. Cash rentals range from \$5 to \$9 per acre. This pernicious system of tenantry is largely responsible for the decreasing fertility.

The average size of farms has increased from 135 acres in 1880 to 161.4 in 1910. The prairie farms are all large. There are more than twenty holdings in the county exceeding 1,000 acres. Farming anything less than 160 acres is considered comparatively unprofitable.

But little land has changed hands in the past five years. The better prairie land is held for \$200 to \$225 per acre. The other sections sell for \$125 to \$200. Measured by its productive capacity, the price of realty is inflated on many types of land.

Truck or special farming has not received much consideration in the county. Suitableness and favorable locations warrant more interest in fruit growing, at least to meet home demands.

The prices paid for farm labor as well as the supply is about the same as that of the general region.

### SOILS.

The soils of Warren County are derived mainly from the unconsolidated deposits left at the retreat of the great ice sheet at the

close of the Glacial Period. When the glacier covered this portion of Indiana, it contained a heterogeneous load of clay, silt, sand, gravel and boulders, in different proportions. The material varied with the character of the rock over which it passed. Foreign and local rocks were ground up and mixed. Upon the melting and retreat of the glacier this load, known as glacial drift, was dropped, leaving an uneven and undrained surface, consisting of numerous knolls, ridges, ponds, marshes and small lakes. Many of the latter became filled so as to be converted into swamps or even dry land, while others continued down to our day. Artificial drainage rapidly converted the swampy areas into dry, tillable land.

The drift is quite variable in thickness, ranging from only a few feet to more than 250. The average is perhaps less than 100 feet. The deeper portions lie on the western and northern side of the area, gradually thinning down as the Wabash River is approached, where the younger sedimentary rocks are exposed.

Two ages or divisions of the boulder till are discernible in the county. The upper exposures of the prairie region are a light or grayish colored, friable, sandy or gravelly clay. The till of the timbered section is prevailingly a yellowish brown clay, containing less coarse material, as a rule. The difference in color may be due to the unequal changes of the iron compounds in the upper strata on account of the relative amount of humic acids and other substances that have been contained in the percolating waters.

The geological epochs represented in the rock platform of the county are the Knobstone of the Lower Carboniferous and the Mansfield sandstone and the Coal Measures of the Carboniferous periods. The Knobstone occurs beneath the drift in the north-eastern corner and is exposed in a narrow strip along the north side of the Wabash from where the river enters the county to Williamsport. The Mansfield sandstone covers a large portion of the eastern half of the county and outcrops along the Wabash and its tributaries from the eastern line to the mouth of Redwood Creek. The Coal Measures rocks lie just beneath the deep drift of the western half of the county.

Generally, these rocks exert no influence upon the soils; but where the drift is thin, as are portions over the Knobstone, they have weathered to a sufficient degree to modify the composition of the soil, and especially the subsoil and substratum. But the extent of purely residual material is very local.

The boulder till is covered with a layer of fine grained loess-like material to a depth of two feet or more. The uniformity of



depth and distribution of this stone free layer strongly suggests that it was transported by the action of wind, probably from deposits of exposed till before it was protected by vegetation or to a lesser extent from the melting and evaporation of glaciers. Flats, hills and valleys alike are invested with this silty veneer covering. The depth may vary somewhat with the surface irregularities, the steeper sloping areas being thinnest and the level and low-lying areas deepest. This silty material, modified by differences in topography and drainage conditions with the consequent variations in the different agencies such as weathering, erosion and vegetation, have given rise to the different soil types of the uplands.

The upland soils have been divided into timber soils and prairie soils, according to the kind of original vegetation. The large amount of humus and consequent dark color is one of the most striking characteristics of the prairie soils. The existence of dark colored soils over areas naturally well surface drained is explained by the absence of timber, which in turn is supposed to be due to the annual prairie fires. But chemical and physical agencies have no doubt influenced or even restricted the growth of trees. Investigations have proved that there is a relation between the high content of lime (that is found in these soils) and other soluble materials and moisture.

The prairie types were separated largely according to topography. The Carrington silt loam covers the nearly level to gently rolling prairie that was naturally fairly well surface drained. The soil color is brown. The Clyde silty clay loam was formed in the lower lying flat areas that were originally poorly drained and in swampy condition. The color is termed black on account of the higher content of organic matter.

The timbered soils are readily distinguished from those of the above region by (1) the general light or gray color, (2) lower percentage of humus, (3) native vegetation, generally timber, (4) more irregular topography, (5) lower average productiveness. These soils are included in two series—Miami and Shelby. The Miami silt loam embraces the gently undulating to rolling areas. A small percentage of this soil has a nearly level surface and was separated out as the flat phase of that type. A zone of eroded and badly hilly land along the stream courses of low agricultural value has been classed as the Shelby silt loam.

The Wabash River is bordered by massive terraces of gravel and sands covered with a veneer of  $1\frac{1}{2}$  to 3 feet of sandy loam, coarse sandy loam, and silt loam. Similar but smaller areas occur

in the valley of Pine Creek. These terraces or benches were built high on the side of the valley by the ancient stream at the melting of the ice sheet. Then they flowed at a much higher level than at present. These soils are divided into three series. The Fox series constitutes the brown or grayish brown originally timbered soils. The substratum of gravel is largely calcareous. The type of the Sioux series is a brown to black, coarse, sandy loam, formed under prairie conditions. In a few areas along the Wabash and Pine Creek, the soil forming material of the terraces is derived from the underlying sand rocks. These areas are correlated as the Allis stony loam.

The alluvium of the flood plains or overflow land is of local origin, being derived mainly from the uplands and has many of its characteristics. The first bottom of the Wabash River is relatively narrow, and the soils are of a grayish brown color, so they were classed as the Genesee. Other typically developed areas of this series are found along the lower courses of the large tributaries. The silt loam and the fine sandy loam are the only members separated. Most of the course of Pine Creek is bordered by some well defined areas of black sandy loam and loam soils recognized as members of the Wabash series. Meadow is a brown mixed loam type found along the minor drainage ways.

Muck is an organic soil formed by the accumulation of remains of various plants, chiefly sphagnum moss. It is of limited occurrence.

The following chapters describe in detail the several soil types.

#### CARRINGTON SILT LOAM.

The surface soil of the Carrington silt loam consists of a grayish brown to almost black, friable silt loam 12 to 22 inches deep, with an average depth of 17 inches. The subsoil is a dull yellow, compact silty clay loam, or clayey silt, passing at about 30 inches into a more friable yellow, sandy clay that contains an appreciable amount of gravel, especially in the lower depths. The type description prevails uniformly over most of the county, but many variations are found where the type grades into the Clyde and Miami soils. In a few small areas in the western part of the county the top soil is quite sandy or loamy, but in areas too small to map as a general rule. In Section 23 and 26, T. 23, R. 10, and S. W.  $\frac{1}{4}$  Sec. 3, T. 22, R. 9, and other smaller spots, the soil is a brown, fine sandy loam or loam, resting on a compact but friable yellowish

sandy clay. The sand content increases with depth until at about 40 inches it is a loamy sand. This phase is found on crest of sharp ridges or on elevated spots in level areas.

The Carrington silt loam constitutes the common rolling prairie land of Illinois and Indiana, and is the predominating type in Warren County. The surface features vary from almost level to undulating or gently rolling. The irregular topography is found on approaching the timber line. Large areas are characterized by a flat or depressed surface, oftentimes so flat that adequate drainage was quite a problem. The crest of the knolls or swells may be only a few inches above the level of the associated Clyde soils where it is developed as islandlike bodies in that type. However, the larger portion of the type has fair to good natural drainage.

On approaching the drainage lines the color of the soil becomes lighter as the humus content decreases, until the color coincides with the Miami soils. This zone varies from one to two miles wide, and originally supported a light growth of timber. It was doubtless at one time a part of the prairie, and the present light color of the soil was produced by the gradual invasion and occupancy by forest growth. This gradation or transitional condition sometimes extends over a considerable strip, and might possibly be considered as another type. But in the present survey it was included in the Carrington soil, for the reason that the content of organic matter is higher than the average Miami soils and is underlain with the characteristic yellowish or buff subsoil of the Carrington member.

The Carrington silt loam was derived from the weathering of the glacial or loessial material intermingled with organic matter, supposedly from the roots and tops of prairie grasses that formerly grew luxuriantly on the native prairies. The depth of the root system is marked by the zone of darkening, which usually extends to a depth of about 18 inches. This high percentage of organic matter has produced a marked contrast in color between the soil and subsoil.

The boulder till underlying the prairie to a depth of 5 to 40 feet consists of a heterogeneous mass of clay, sand and gravel of light grayish color. The contents of coarse material increases from the subsoil downward and the deeper substrata are usually quite stony.

The type is extensively developed in the western and northern portions of the county. The inner boundary of this type represent-

ing crudely the former timber line, will average about five miles back from the river front. It attains its best development in Ranges 9 and 10. In Mound Township it approaches within two miles of the river. It invariably extends up to the creek valley on the west and south side, while the corresponding area on the north and east are timbered soils.

This county lies in the path of the prevailing southwesterlies of summer and autumn. This condition is perhaps the result of the check given to the advancing prairie fires by the creek and valley slopes.

Besides the artificial planting of silver maple and osage orange there are a few islandlike groves of native forests of oak and hickory through the prairie. The largest tract occurs in Sections 35 and 36, T. 23, R. 9, known as Walnut Grove.

Generally, the subsoil is well oxidized and is a buff to bright yellowish color on the ridges and knolls, and a pale yellow or gray and highly mottled with yellow and iron stains in the level portions. The mottled condition is always associated with poor drainage. An extensive area with the mottled subsoil occurs east of Pine Village, extending well toward the eastern boundary line. The surface soil of parts of this development is a grayish brown or brown heavy silt loam, resembling the flat phase of the Miami silt loam.

Most of the area lying north of Pine Creek and east of Mud Pine Creek is broken by morainic ridges and a lighter colored surface soil is developed. A few such areas were separated as Miami. The soil in such Carrington areas consists mainly of 12 to 30 inches of a grayish brown silty loam, grading into a friable brownish yellow sandy loam. Below two feet there is considerable sand and gravel. The surface also carries varying amounts of cherty gravel.

Granite boulders were numerous on this type in Prairie Township in Sections 35 and 27. A boulder trail was said to have existed in a belt about one mile wide passing from the northwest to the southeast, but could not be traced. Most of the boulders have been removed so they do not now interfere with cultivation.

The soil and subsoil have a remarkable capacity to absorb and retain moisture. The compact silty clay layer between the depths of 18 and 36 inches serves as a reservoir to hold the percolating waters. The same structure also insures good capillarity. This, combined with the good internal drainage induced by the friable sandy clay substratum, enables the soil to withstand drought to a marked degree and also does not suffer from excessive rains. How-

ever, many fields of this land would be benefited by an extension of the tile drainage system.

Formerly the Carrington silt loam was one of the most desirable and productive soils of the corn belt, but much of this type as well as the Clyde silty clay loam has been subjected to continuous grain farming for about thirty years, until now its fertility and productiveness has begun to wane. In addition, its former good physical condition has been reduced by improper cultural operations. The corn stalks are often pastured in later winter and spring when the tramping puddles the soil. Ofttimes it is plowed too early, before dry enough to handle safely. The organic matter is depleted by the burning and sale of the crop residues, such as stalk straw and weeds. Every effort should be made to increase the supply of humus. Clover or soy-beans should be grown in every rotation and the bulk of the crop turned under, either outright after threshing, or in manure. The oat straw should be returned to the soil if not utilized as feed or bedding.

The Illinois station has found this type to be deficient in phosphorus, and good results are reported in the adjoining counties of that State by applications of one-half to two tons of raw rock phosphate.

The lighter phases of this type, and particularly the undulating areas, are becoming low in lime, as shown by the litmus tests; and all evidence seems to indicate that lime is needed, and profitable results will doubtless attend its use.

Corn, oats, grass and wheat are the main crops grown on this type. A five year average for corn would be about 40 bushels; oats, 30 bushels; wheat, about 20 bushels, and clover, 1 to 2 tons. No attempt has been made to grow special crops except a small acreage of potatoes, which give about 200 to 300 bushels per acre. Sugar corn is grown extensively on this soil around Hoopston, Illinois. It is an excellent grass soil, and a considerable acreage is in blue grass, especially in the rolling areas and near the timber line. Some fruit is grown for home consumption, but deserves far more attention.

Wheat is not generally grown. It winter kills badly, either by the accumulation of water in low places or smothered out by the ice in winter. Wheat plants are also heaved out of the ground by the alternate freezing and thawing in the fall and spring. This is due to the formation of ice in soil spaces filled with water. Winter killing is a sign of inadequate drainage. With the improvement of the drainage system and the use of hardy strains of Turkey Red,



wheat culture could be profitably extended to this type. Alfalfa, soy-beans, cow-peas and sweet clover are admirably adapted to this land.

The Carrington silt loam is the prized farming land of the Grand Prairie and commands from \$150 to \$225 per acre.

This series constituted what was formerly called Marshall.

#### CLYDE SILTY CLAY LOAM.

The Clyde silty clay loam embraces the lower lying, flat areas, originally swampy or inadequately drained. This type is intricately associated with the Carrington silt loam, and also occurs as depressions through the Miami silt loam.

The surface soil to an average depth of 12 inches is a dark brownish gray or black heavy silt loam to silty clay loam. The content of organic matter is relatively high; it consists mostly of black humus, which imparts the granular character and keeps the soil mellow. As the content of humus is reduced by cultivation, the power of granulation is lessened and the soil becomes heavier and more difficult to handle. The intensity of color is proportionate to the amount of organic matter and moisture present in the soil. Why dry the surface is a deep chocolate brown, but changes to an intense black color when moistened.

The subsoil is a dark gray to drab or bluish black clay loam which grades at 18 to 24 inches into a gray plastic silty clay mottled with yellow, brown, and iron stains. The mottlings become more pronounced with depth and the silty clay becomes more plastic and tenacious in lower sections. Occasionally below 30 inches a gravelly or coarse sandy clay is encountered. The subsoil has no constant characteristics and is subject to wide variations, especially in color, over short distances. The plastic and mottled condition is the result of poor drainage and consequently bad aeration and oxidation. This internal characteristic of the subsoil readily separates it from the Carrington silt loam.

The type as a unit perhaps will average a heavy silt loam in Warren County. Most of this soil presents very wide variations from the brown prairie and the differences are so pronounced as to be recognized by most farmers. It is locally styled black prairie, and the heavier development is known as "gumbo". The value of realty is determined largely by the acreage of this type on the individual farms. In most instances the boundary is fairly distinct between this type and the associated Carrington silt loam. But there is frequently a zone or strip between the two soils that gives

rise to a lighter phase containing less clay and organic matter than the Clyde type. The Carrington subsoil is frequently present and may continue inward some distance under the Clyde soils.

Local areas of this soil are a heavy black clay loam to a depth of 12 inches, passing into a granular bluish black clay loam to about 18 inches. This gives way to a heavy drab silty clay highly mottled with yellow blotches. This phase is found only in the lowest depressions. It is generally so wet and intractable that it is not cultivated. A few such acres are found in Sec. 35, T. 22, R. 9; another in Sec. 4, T. 22, R. 9, and a large body in Sec. 29, T. 20, R. 10.

Quite a high percentage of the type occurs bordering the minor drainage ways of the prairie, and larger creeks and along the lower courses of the streams where they begin to form a channel. The material resembles an alluvium, and is underlain with a highly stained sand and gravel at about three feet. Such an area is found in Secs. 16, 17, 8, 9, T. 22, R. 9; also in Sec. 12, T. 22, R. 10.

The soil along Jordan Creek is a black silty loam from 6 to 10 inches deep, underlain with a bluish black, friable or sometimes gummy silty clay loam or clay to a depth of 8 to 22 inches. This grades into a very sticky, plastic drab or dark mottled silty clay. The soil and subsoil contain more gravel. These bottoms are subject to overflow in times of heavy rainfall; but on account of the similarity of the texture and structure (as most of the soil has come from this prairie) as well as agricultural adaptations, they were included in the series which is typically developed in the structural depressions of the uplands proper. The origin of this type is traced to the former wet prairie conditions under which it was developed. The low lying portions received the fine materials and organic matter washed in from the slightly higher uplands. The rank growing sedges and grasses added much vegetable matter to this soil. More or less of the clay and finer silt has been translocated to below the surface and accumulated in the lower soil and subsoil sections. This has been the work of centuries, beginning after the recession of the great ice sheet. Exposure of the surface after the periodical prairie fires accelerated the surface wash. The same agency (washing) is very active at the present time, and its influence can readily be observed on this type where it is contiguous to rolling areas.

The early settlers found this soil in a waterlogged condition. It then constituted the sloughs or wet prairie. Most of the type has been under cultivation less than thirty years. Tile drainage began about 1882 and gradually extended until all the type was reclaimed, so that now most of the type is well surface drained except

a few ponds. Most of the large ditches now remaining open could be supplanted by underground drains.

The type is best developed in the western one-third of the county. Representative areas are found north of Tab, south of Pence for a distance of six miles, and in the southwest corner of the county. The timbered phase is not extensive; the largest bodies occur in a strip about two miles in width at the south edge of the Carrington soils in Warren Township. The soil in the larger bodies of the timbered phase is not essentially different from the prairie soil.

The greatest problem in managing the Clyde silty clay loam has always been to secure a good drainage; but as previously stated this difficulty has been overcome by artificial drainage. But there is urgent need for more lines of tile, especially so in the parts of the type having a gummy subsoil.

As a rule this soil does not seem to be very generally acid; but traces of acidity have been found with litmus paper. The subsoil is well supplied with lime. The phosphorus and potassium contents are known to be ample in most cases. The needs of the type for some time to come will be better physical treatment, and a constant supply of decaying organic matter should be maintained to improve the mechanical condition of the soil. Applications of limestone and phosphorus may eventually prove profitable.

The Clyde silty clay loam has endured the continuous grain farming unusually well. It is the premier corn soil of the corn belt. The average yield from this type is about 55 to 60 bushels, while 70 to 80 bushels are common. Oats will average about 40 bushels, with an occasional maximum yield of 80 bushels. These two crops have occupied the land either continuously or alternately for over twenty years until some fields show marked signs of decreasing production.

Farms containing a large portion of this type are held for \$150 to \$225.

The Clyde silty clay loam varies markedly from the same type in central Indiana. The most salient character of the former development are the greater depth of the surface soil. The color as an average is more intense and extends to a greater depth. The texture is notably lighter.

#### MIAMI SILT LOAM.

The surface soil of the Miami silt loam to an average depth of 8 to 12 inches is a gray to a brownish gray silt loam; incoherent

and mealy, but not granular, and quite deficient in humus. The soil rests upon a gray or yellow silt loam that extends to a depth of 18 to 24 inches. This is likewise mealy, but becomes more granular with depth as the clay content increases. This layer resembles the soil very closely in texture, but is readily distinguished by its lighter color. The average depth of the silt is 17 inches; the soil is composed chiefly of silt and very fine sand, with but a small percentage of the grades above fine sand. Limited quantities of cherty gravel and stone fragments occur on the surface and through the soil section, but such material is not frequent except on the steeper slopes, and on the crest of sharp ridges or mounds. The organic matter content is everywhere markedly low, perhaps averaging less than two per cent. This deficiency of humus is evidenced by its characteristic color. It gives a grayish or whitish color when dry, but changes to a dull gray or light brown when slightly moistened. Iron concretions are found on the surface and disseminated throughout the soil and subsoil in local areas of small extent. The soil is very compact but friable and porous when in good tilth.

The subsoil is a yellowish brown, compacted silty clay loam, grading at a depth of about three feet into a more friable clay loam. The content of gravel and sand usually increases to a depth of four to five feet, so that the substratum is often a sandy clay. The average thickness of the compact, dense layer is about 18 inches. Sometimes at a depth of twenty inches a gravelly clay is encountered. In such situations the coarse stony material increases rapidly, until the subsoil becomes quite open and permeable. This condition obtains along the largest stream courses, where the glacial materials have been assorted and rearranged in stratified deposits.

The prevailing subsoil of this type is well oxidized, as is evidenced by the characteristic brownish tint, but gray streaks or mottlings are common. These mottlings are closely associated with the denser and poorly aerated plastic subsoil, and when dry it may become so hard as to offer considerable resistance to the penetration of soil auger or implements of tillage. Naturally it is seldom so compact as to prevent a downward movement of excess water; at the same time the layer is so retentive that it acts as a reservoir for the storing of soil moisture.

The material composing the Miami silt loam has been derived from the weathering of the silty mantle that everywhere invests the boulder till to an average depth of 30 inches. The gray color of the soil is a result of leaching and slow accumulation of humus that follows a long continued occupation of a heavy growth of

timber, all the type being originally forested with white, red, scarlet and shingle oaks, hickory, sugar maple, and poplar; the dominant species are white oak and hickory. With the exception of a small acreage of woods pasture, the type is now all cultivated.

The topography for the most part is wavy or flowing and sufficiently rolling in places that considerable washing may occur if not properly managed. Near West Lebanon the relief is quite pronounced, consisting of high morainic hills and ridges. North of Independence the type occupies some broad gentle elevations, distinct from the other topographic features of the county. The surface of other portions is interrupted only by pot or kettle-hole-like depressions.

In some places, as east of Independence to the county line and up Kickapoo Creek, the Miami appears to occupy a high terrace, but the soil structure disproves this origin. In Secs. 8, 9 and 4, T. 22, R. 6, the soil is a pale ashy gray silt loam to a depth of 10 to 12 inches, passing abruptly into a gray, heavy silty clay loam, mottled with yellow and iron stains. At about 30 inches the subsoil grades into a grayish or drab, silty clay, containing shale fragments. At about two feet bed rock is encountered. The subsoil seems to be largely residual. This phase is not very productive; it is much in need of lime, drainage and organic matter. The surface features of the type give it good natural drainage. However, more extensive tile systems seem advisable even on the gently rolling areas, to improve its physical condition.

The Miami silt loam occurs in one continuous body, fronting the Wabash River. It extends back from the river to an average distance of five miles; continues up Pine Creek in a broad belt, but does not reach far north of that creek. It extends in narrow strips along the drainage lines, being widest on the west and north side of the valley. A few other isolated bodies occur in the prairie types. The boundary or zone of land that represents the transition of this type and the prairie is not clearly drawn in most places. The topography usually becomes level on approaching the prairie and in some places the change is abrupt, being marked by a low sharp descent to the darker soils. The gray, gravelly till of the prairie may pass under this type for some distance, gradually giving way to the brownish yellow till of the timber section.

In normal seasons, corn will yield from 30 to 40 bushels per acre. Oats usually give less than 40 bushels. Wheat is generally recognized as the crop for this soil, and where good cultural methods are practiced averages of 20 to 35 bushels are obtained. Hay



gives from one to two tons per acre. The yields as a whole are lower than the prairie types, but the products are of a superior quality.

The largest per cent. of owners farm their own land on this soil than any other type. The farms are smaller; systematic rotations are practiced, and more live stock is kept than in other sections. Some portions are not so prosperous; this is true only in the region about Possum Run and near Independence.

Organic matter is the first need of this type. It will prevent the soil from running together and improve its moisture holding capacity. Much of the soil is subject to seasonal extremes. The drought of 1914 reduced the average yield of corn in numerous fields to 5 to 10 bushels. Since humus is the limiting factor on the main soils every effort should be made to have a constant supply.

Applications of one to two tons of finely ground limestone are to be recommended, as most of this type shows a pronounced tendency to become acid. The phosphorus supply is known to be low, and should be strengthened by the addition of acid or rock phosphate.

Land values of this type range from \$125 to \$200 per acre.

The Miami silt loam in Warren County is much deeper than the soil as mapped by the survey in central and eastern Indiana. The average depth of the compact silty clay layer is about 18 inches as compared with 8 to 12 inches in the latter location. The subsoil is also better oxidized and lacks the mottled condition that is so prevalent farther east.

#### MIAMI SILT LOAM—FLAT PHASE.

The flat phase of Miami silt loam is not extensively or typically developed in Warren County. It occurs only in few areas large enough. The largest of these is found in Mound Township, and near Green Hill. The topography of this type varies from nearly level to gently undulating, and is less perfectly drained. It is of same origin (weathering of till) as the type.

The surface soil to depth of 8 to 10 inches is gray to brown silt loam underlain to depth of 20 inches by a light gray and mottled heavy silt loam to silty clay loam. This grades into a grayish-yellowish mottled silt clay containing more gravel and sand than above section. The subsoil may be somewhat plastic and sticky but is more friable in the lower depths. Iron concretions are common in both soil and subsoil. The surface soil of the flat phase is nearly identical with that of the type, the separation being based mainly upon the poor drainage conditions and mottled nature of the cold,

tight subsoil. However, the surface soil usually shows a whitish or leached appearance, especially on the more elevated portions. Frequently where the soil grades into the Clyde silty clay loam the subsoil becomes heavy, it being a drab silty clay highly mottled with iron blotches. The soil in such places is a heavier silt loam containing a larger amount of organic matter than the type.

The topography is so level locally that adequate drainage is quite a problem. However, greater portion of phase has sufficient slope to afford good chance for tile drainage. The soil and subsoil of this phase is very generally acid; this deficiency in lime, coupled with lack of organic matter, has impaired the physical condition of soil to the extent that it has a tendency to run and clod badly. Deep rooting crops, such as red, big English, or sweet clover would assist in loosening up and aerating the dense subsoil. All crop residues and if possible a crop of rye should be turned under occasionally to restore and maintain a good tilth. An application of one-half to one ton of ground limestone per acre is recommended in connection with organic matter for this type.

The flat phase is used for the same crops as the Miami silt loam, but the yields are somewhat better. The improvements on this soil are splendid and the land commands about the same price as Carrington silt loam.

#### SHELBY SILT LOAM.

The Shelby silt loam is a rather general type, embracing the soils found in the portions of the uplands that are very hilly and badly eroded, and cannot be used for ordinary cropping purposes very satisfactorily. The separation from the Miami silt loam is based almost entirely on topography. This varies from rolling to broken. On approaching the Wabash River the region is deeply dissected by the larger streams and their tributaries. They often acquire steep or precipitous slopes, sometimes walled in by perpendicular bluffs of sandstone. These bluffs, as well as the Wabash valley escarpment, are often 80 to 150 feet high. The most extensive areas are found along Possum Run, Redwood, Pine, Stony Creek and their tributaries. This soil is shown on the map in narrow bands, paralleling the valleys, or as finger-like projections in the Miami soils.

The surface soil ranges from a brown sandy loam to a yellowish gray silt loam to a depth of 12 inches. The subsoil is a yellowish brown to reddish brown compact silty clay loam to clay. The soil and subsoil have variable amounts of gravel, depending upon the

extent of erosion. Running water has been very active in modifying the soil materials since their deposition, and more so since the land has been cleared and put under cultivation. The original silty mantle has been bodily removed from the steeper areas, exposing the underlying yellow silty clay or boulder till.

Included with this type are narrow patches of arable land, but the individual area of tillable fields is generally too small to be shown separately. The steep slopes break abruptly into the level plain which may extend even to the very brink of the slope. In a few instances the slopes cannot be represented on a map of the scale used in the survey. In most cases the width of the boundaries is exaggerated in preference to being omitted, mainly for the purpose of emphasizing their influence on farm values.

In the northeastern part of the county along the river, the Knobstone shales have influenced the topography and to a lesser extent the soils. The surface has eroded into the characteristic knob-like topography. The boulder till is often a grayish or bluish color, much like the color of the shale. In the same region the Mansfield sandstone has profoundly affected the surface configuration. Besides the exposures in the valleys, it is found capping the hills and narrow divides in a few places. A bold outcrop occurs at Black Rock that rises to about 140 feet above the river.

Under ordinary methods of cultivation this type is subject to serious loss from surface washing, and even where untilled there is more or less rapid erosion taking place. Some of the areas should never have been divested of their forest cover. Only a small percentage now possesses a protective covering of trees. In the management of this land, the following methods are at the disposal of the farmer to protect his fields against erosion: (1) Contour or circle plowing, and deep plowing; (2) better rotation, lessening the number of tilled crops and making larger use of fine rooted grasses; (3) actual tile drainage of the slopes, especially laying tile drains in gullies; (4) laying out of the hillside in narrow plow lands at right angles to the slope, cleaning out the dead furrow and leading them into sodded swales; (5) terracing and making side hill ditches where necessary and profitable.

The underlying boulder till is rich in the mineral elements of fertility, so the only problem of fertility is to increase and maintain the organic matter in the soil by the use of both animal and green manure.

This soil is suitable for fruit growing. The general experience with fruit in the county, together with the presence of old, healthy

and productive trees on this and similar types, seems to be a safe guide for an extension of fruit production on this soil.

The price asked for this land is from \$20 to \$125 per acre.

#### FOX SILT LOAM.

The Fox silt loam consists of a brown or grayish brown friable silty loam to a depth of 8 to 18 inches, underlain with a brown gravelly loam, coarse sandy loam, or gravel. The depth of the gravel is quite variable; the average depth is perhaps 18 inches; sometimes it is reached at 12 to 15 inches. On the low mounds or swells the gravel comes to the surface. There are numerous small areas covered with rounded cobble-stones about four to eight inches in diameter. Most of these have been removed and the soil put under cultivation. The surface ordinarily carries quite a bit of whitish and cherty gravel, easily seen strewn over the ploughed ground, but not so noticeable on boring. The surface soil while predominantly a silty loam varies locally to a gravelly loam or gravelly sandy loam. The extent of these types is so limited and so badly mixed that it was impractical to separate them. The color is likewise variable; the best defined areas are much darker than the small bodies which resemble more the uplands. However, in all places there is enough organic matter to darken the surface and make the soil granular.

The Fox silt loam embraces the greater portion of the Warren County terraces. It occurs as a broad level plain along the Wabash some 30 to 75 feet above low water mark. It begins just above Independence and widens out westward until a maximum width of one and one-half miles is attained. It ends almost abruptly at the valley of Kickapoo Creek. It appears again below Williamsport and continues southwest to about a mile below the mouth of Redwood Creek. The average width of the lower terrace known as the Barrens is about one and one-fourth miles. It is clearly defined from the upland by a high bluff line to a point near the Wabash Railroad, where it ascends gradually to the uplands. The terraces above Pine Creek are not very sharply differentiated from the adjoining Miami silt loam. The long gentle slopes of the uplands merge almost imperceptibly into the terraces. Near this boundary the soil is of same character as the uplands, and substratum resembles the boulder till.

The massive beds of gravel and sand composing these terraces are of remarkable thickness. They range in thickness from 75 to 100 or more feet. The supply of gravel is almost inexhaustible.

Two gravel companies operate near Kickapoo. The gravel is largely different kinds of granite rocks, although a high percentage is limestone. It varies in size from fine sand up to stone six inches in diameter, with occasional large boulders.

The high gravel terraces were formed when the river flowed at a much higher level than at present. At the melting of the Wisconsin ice-sheet great floods were formed which were heavily loaded with glacial debris, and it was deposition of this increased supply which built the former broad flood plains. When the ice withdrew and the excessive supply became exhausted, the velocity of the stream began to diminish and finer material was deposited over the gravel forming the veneer of soil.

The surface configuration varies from level to gently undulating. The level areas are found mostly bordering the uplands, while the central and outer portions are more irregular. The most conspicuous inequalities are found by the streams flowing from the uplands.

The lower four to six inches of the soil section is just a shade lighter and perceptibly heavier than the upper 12 to 14 inches in the typical development. There is a limited area just south of Williamsport in Sec. 22, T. 21, R. 8, that has a dark brown soil to a depth of 12 inches underlain with 12 inches of light brown silt loam. The subsoil is a compact brown and gray mottled silty clay loam from 24 to 42 inches. The moisture conditions of this phase are good and yields are larger than the type.

While the prevailing substratum of the type is the unconsolidated deposits of gravel, a few areas rest on rock at a shallow depth. The terrace in Secs. 8, 9 and 4, T. 23, R. 6, is underlain with the Knobstone shale at depths varying from one to three feet and the decayed shale fragments are found in the soil section. The terraces above Independence to the Tippecanoe line are underlain with the above formation, and have profoundly influenced the texture and productiveness. The soil is a pale grayish heavy silt loam to 8 to 12 inches, underlain with a compact gray mottled silty clay loam subsoil that gives way in turn at shallow depths to a shaly substratum. Large boulders are frequent over the surface. The soil in these locations is a poor one and used largely for pasture.

The Fox silt loam is friable and easily reduced to a fine seed bed, but compacts readily after rains or when allowed to remain unstirred any length of time. The greatest problem in the management of this type is the conservation of moisture. It is a greater one than fertility. The soil naturally is fertile, but on account



of the subsoil the drainage is excessive and not very productive. This structure in conjunction with the frequent droughts in critical periods of crop production makes it imperative to make best use of the water that falls. This is accomplished by applying the principles of storing water in the soil; (1) the surface should be kept in a condition to catch the rains; (2) it should be cultivated to keep it loose and rough, thus reducing evaporation; (3) the weeds should be kept down so far as possible, both before and after seeding to prevent their use of water. When the gravel is so near the surface it is impossible to store sufficient moisture in such a shallow soil to carry the crop through a long dry spell. As soon as the moisture stored in the soil is exhausted the crop will suffer or die according to the length of the drought, but the above measures would not come amiss.

It is suggested that the small grain stubble be plowed or disked after the removal of the crop to kill weeds and get the surface in condition to hold moisture. Crops which will withstand considerable drought or escape drought by maturing early are recommended.

Live stock as a medium for marketing the crop and to insure an income during unfavorable years is essential to the success of farmers on this type.

The soil is devoted to the crops common to the region. The yields depend entirely upon the rainfall, more especially corn, oats and hay. In a normal year oats yield from 30 to 50 bushels and corn 40 to 60. The latter crop is most uncertain. In the season of 1914, large areas yielded only 5 to 20 bushels. In the past five years the loss on this crop has been enormous. Wheat is the most certain and profitable cereal grown; 10 to 40 bushels are secured. This type is well adapted to blue grass, and a larger acreage should be given over to permanent pasture.

Ground limestone is being used and phosphatic fertilizers are being tried on wheat with varying degrees of success. The greatest need is humus and this should be increased in every conceivable way. The value of the Fox silt loam ranges from \$75 to \$150 per acre.

#### GRAVELLY PHASE.

This phase includes the portion of the "Barrens" or terrace from Rock Creek west to Redwood Creek. The separation was deemed necessary on account of the more gravelly and shallow soil of this area as compared with the remainder of the type. The sur-

face configuration is uneven, consisting of two or more well defined terraces or benches.

The surface soil ranges from a grayish brown sandy or gravelly silt loam to loam, to an average depth of 8 to 10 inches, grading into a brownish gravelly loam or gravel that continues to an unknown depth. The content of gravel in the surface is quite noticeable, and far in excess of the amount found on the type. The shallower soil makes it very susceptible to drought, and the yields are somewhat less than secured from the better portions of the type.

This terrace is known as the "Barrens" but was heavily forested at one time.

The improvements are good, and same prices are asked as for the Fox silt loam.

#### FOX SANDY LOAM.

The surface soil of the Fox sandy loam is a gray to light brown medium sandy loam to a depth of 18 to 24 inches, more often the latter depth prevails. The subsoil is a yellowish brown coarse sandy loam to gravelly sandy loam or loam. The substratum consists of stratified beds of gravel and sand. It occupies terraces that are fairly well defined. The largest unbroken area is found three miles southwest of Williamsport. Here it is found adjoining the upland slope. It is somewhat higher than associated Fox silt loam. Its surface is not so regular as the silt loam member, and is frequently interrupted by minor inequalities. It rises from the Fox silt loam in a billowylike ridge, that resembles an accumulation of wind blown material.

The areas along Pine Creek mapped as Fox sandy loam do not occupy as clearly defined terrace positions as the ones mentioned above. The plain is notably above overflow, but the texture and structure is somewhat characteristic of a flood plain. Most of the surface is from 8 to 20 feet above the level of the creek. The largest body along Pine Creek is found at Kramer. Here the soil is quite mixed in texture and structure. It consists for the most part of a brown friable sandy loam or fine sandy loam to a depth of 12 to 15 inches, grading into a brown heavy loam or gravelly loam. The content of gravel varies widely in the 3-foot section. Near the uplands the material may be a silt loam or loam to 8 to 12 inches that passes into a compact gravelly loam or gravel. Nearer the stream channel the soil becomes a gray to brown, medium incoherent sandy loam or sand with but little change in the 3-foot section

except the color of the subsoil, which is a shade lighter. This phase is open and loose and may become droughty.

The area in Sec. 33, T. 23, R. 8, is underlain with the Mansfield sandstone. The soil to a depth of 12 inches is a gray sandy loam underlain with a bright yellow or cotton seed meal colored sand or loamy sand that appears to be residual from the underlying formation. It is subject to drought on account of the substratum.

The type as a whole is fairly well supplied with organic matter, as is shown by the characteristic brown color of the soil. The color becomes more pronounced away from the creek. The drainage is good, often excessive, so that in dry seasons the crops suffer from lack of moisture. The areas along the Wabash are subject to this danger, but the Pine Creek bodies have a greater moisture holding capacity.

Most of the type is regularly farmed to the staple farm crops. The soil contains sufficient coarse material to render it open, loose and easily tilled with light equipment. Corn will average about 5 to 40 bushels; oats, 10 to 30 bushels; and wheat less than 15 bushels. Melons of an excellent flavor are produced on the fine sandy loam phase. Alfalfa thrives well. Portions of this type having a loamy subsoil are well adapted to truck crops, and with judicious fertilization and management could be profitably handled in these crops. The type stands in need primarily of more organic matter, which can best be supplied by growing such crops as rye, soy-beans, clover or other legumes. Potassium fertilizers could be applied with profit on some fields.

#### FOX GRAVELLY SANDY LOAM.

The soil of the Fox gravelly sandy loam consists of a brown medium sandy loam, containing a large quantity of calcareous gravel and coarse sand. The subsoil is a yellowish brown, very gravelly sandy loam. This in turn gives way at a depth of two feet or more to stratified beds of gravel and sand that extend to an undetermined depth. The gravel is often so abundant as to literally cover the surface, and is especially prominent and noticeable after heavy rains, and in cultivated fields where the water has washed away the finer materials. Most of the gravel particles do not exceed one-fourth to one inch in diameter. The interstitial material is fine sand and silt.

The drainage is good to excessive. The soil may be worked under a wide range of moisture conditions and a fine seed bed can be secured. The gravel to a certain extent prevents packing and

baking of the soil, and insures better tilth through the growing season with a minimum of cultivation. These same conditions cause the soil to be droughty in years of low rainfall, and so the yields are uncertain; but during seasons of normal rainfall good yields are obtained. Only early maturing crops should ever be grown on this type. Of these, wheat seems to be the most profitable.

In the management of this soil, care should be taken to increase the humus content of the soil. This, together with shallow cultivation, would assist the growing crops to resist droughty conditions.

The Fox gravelly sandy loam occupies terrace levels along Pine Creek and the Wabash River. It is of very limited extent. The most typical body is found in Sec. 4, T. 22, R. 8, along Pine Creek. Other areas are distributed through the Fox silt loam along the Wabash.

#### SIoux COARSE SANDY LOAM.

The surface soil of the Sioux coarse sandy loam is a dark brown or black, rather heavy coarse sandy loam to an average depth of 13 inches. The content of organic matter is relatively high. The subsoil from 12 to 20 inches is a yellowish brown compact coarse sandy loam or light loam in which there is a high percentage of coarse sand and fine gravel. The content of gravel is first noticeable at 20 inches and increases with depth. Below two and one-half feet the substratum is a bed of sand and gravel extending to a great depth. The substratum as exposed in the gravel pits was a mass of gravel and sand some 40 to 60 feet thick, resting upon a shelf of shale. The gravel is of a good quality for road surfacing and railroad ballast. Extensive pits have been worked in this type; the largest pit belongs to the Big Four Railroad. The gravel is largely of igneous origin but perhaps as much as 30 per cent. is limestone.

The terrace rises about 50 feet above the Wabash River. The surface is level to very gently undulating. Its average width is about one-half mile, and is about one and three-fourths miles long, and extends southward into Vermillion County about two miles. It is known locally as Mound Prairie. Its origin is similar to the remainder of the high terraces along the Wabash. It is a remnant of a former flood plain that was formed at the melting of the glacier, below which the river has cut its channel.

The western boundary of this terrace is marked by a distinct bluff line of the rolling uplands. However, it is separated from the upland types by a strip of the Fox silt loam. This border strip has

resulted largely from the material washed from the adjoining slopes either by sheet erosion or the intermittent streams that come from the uplands.

The surface soil is remarkably uniform; apparently it is a coarse loam, but carries a high percentage of coarse and medium sand and gravel. These particles seem to be in an advanced stage of disintegration, as they can be readily pulverized between the fingers. On examining the soil in a moist condition, numerous small white particles are seen, which are probably limestone in a state of partial decay. While the amount of coarse material is large, there are sufficient fine interstitial materials, as clay and silt, to produce a structure favorable to the retention of moisture, but the droughtiness results from the subsoil. The soil materials are wonderfully coherent. Areas allowed to remain uncultivated become so compact as to be almost impenetrable with a soil auger and offer considerable resistance to the plow, although when cultivated under proper moisture conditions it is quite friable and easily brought to a good tilth.

Corn, oats, wheat and clover are grown with more or less success on this soil.

Corn probably occupies the greater acreage. The average yield in years of sufficient rainfall is about 40 to 70 bushels. These may go as low as 10 to 20 bushels in years of drought; oats from 30 to 50 bushels, and wheat 12 to 25 bushels. Clover is subject to winter killing, and is not often used.

The moisture conditions in early summer are generally good. Corn makes an early start and does well until tasseling time, when it begins to suffer if the rainfall is short. Of the principal farm crops, wheat seems to be the most satisfactory crop for this soil and should receive more attention. Sweet clover and possibly alfalfa could be made a profitable crop on this type.

The Sioux sandy loam just across the river is devoted to strawberries, raspberries, peaches and market garden crops. These find a ready market at Danville. Truck farming might be profitably undertaken on this area.

None of the Sioux coarse sandy loam can be secured for less than \$150 an acre on account of the proximity to Covington.

The prevailing dark color is no doubt due to the prairie condition which existed. It contrasts with the light brown color of the typical Fox soils which were found on the timbered terraces. The State experiment station farm is located on a phase of this type.



## GENESEE SILT LOAM.

The Genesee silt loam consists of dark gray or grayish brown to rather dark brown mellow silt loam to a depth of 12 to 42 inches. The soil grades gradually into the slightly heavier and lighter colored subsoil at an average depth of 18 inches. There is but very little change in color with depth, but the texture becomes perceptibly heavier as the clay content increases. The lower section is oftentimes a heavy silt loam, grading in places into a brown and gray mottled heavy silty clay loam. The immediate substratum is variable, ranging from pure sand to gravel. Beds of gravel were encountered at a depth of 20 inches in places.

The color of the Genesee silt loam is very uniform. It does not contain a very high percentage of organic matter. At the mouth of some of the larger creeks the soil may be darker in color and more loamy.

The soil varies from a loam, where contiguous to the stream, to a silty clay loam next to the uplands or in local depressions. The Genesee silt loam is the principal bottom land of the Wabash River. It occurs in this area in a strip averaging much less than one-half mile in width with a maximum width of only three-quarters of a mile, with slope toward the river. The surface is mainly level, but may be uneven, due to the presence of overflow channels and sloughs. There may be ridges of sandy material intermingled with this type. The widest variation in texture is near the stream, where the water is more active. This type is subject to periodic inundation. The high waters are most troublesome in early spring; the water oftentimes remains on the surface until as late as the last of April. Also it not infrequently happens that the land overflows after the crop is planted. This was observed in May, 1914. The grown crop is sometimes lost by floods in August or September, but this is rare. The bottoms are so late in drying out in spring that by the time the ground is plowed the danger of floods is past. Otherwise the natural drainage is fair. There are a few depressions that are permanently wet. These are mapped as meadow. The long sloughs cut up the land and retard cultivation. Plowing is begun next the stream and worked toward the upland.

Corn is the only crop grown, and produces large yields of a good quality. Seventy bushels is considered a good average, although averages of 80 bushels are not uncommon. The season of 1914 was unfavorable and the average was less than 50 bushels.

This type is easily tilled and can be easily worked into a fine

seed bed. The soil is mellow and friable, but sticky when wet, and has a tendency to clod when plowed too wet.

The matter of clean cultivation is made difficult by the frequent flooding that introduces large quantities of noxious weed seed, such as the wild sweet potatoes, morning glory, and cockle burr.

Farming is upon an uncertain basis, on account of the annual overflow. The small area of the bottoms would hardly seem to justify the outlay for a system of levees or dikes. In the management of this type, no soil treatment is needed except good farming and where the land is subject to annual overflow the rotation of crops is not essential.

Winter crops cannot be grown.

The surface is mostly level but many minor irregularities occur such as always characterize a flood plain.

The Genesee silt loam is developed sometimes in swales bordering the uplands along some of the larger tributaries of the river.

Areas at the foot of the upland are frequently gravelly. Other portions at the mouth of the small ravines are covered with shale fragments from the uplands.

These areas of colluvial wash or alluvial fans, whenever of sufficient extent, are planted in oats or alfalfa.

#### GENESEE FINE SANDY LOAM.

The Genesee fine sandy loam consists of a grayish to light brown fine sandy loam to a depth of 12 to 20 inches, containing but little clay and silt and large amounts of medium and coarse sand, underlain with a brownish yellow or brownish gray fine sand loam or loamy fine sand. The loamy material gradually decreases with depth, and at about 24 to 30 inches a clean gray or brown sand is often encountered. No definite line can be seen between soil and subsoil. The latter consists of essentially the same kind of materials but the color usually becomes lighter with depth.

The principal occurrence of the type is along Possum Run, Redwood and Little Pine Creeks. In these places it occurs as strips of overflow on first bottom land. It is also developed in small isolated areas along the Wabash River. In the latter location it exists in low alluvial ridges or natural levees on the bank of the channel. They are formed in times of flood when the river overspreads its plain, and the banks are the site of active deposition, due to the first check of the velocity of the flood waters. The patches are usually narrow and rise a few feet above the associated Genesee silt loam. When developed as a natural levee the sand

may be oftentimes of medium texture with but little change in color in the three-foot section.

The surface of the type is quite uneven, especially so along Possum Run and Redwood creeks, consisting of low knolls and ridges and shallow depressions. A few level fields occur, but these are not extensive. A large part of the tract is subject to frequent overflow on account of the high gradient of the streams and narrow valleys. A few such areas are so dissected by the creek and the surface covered with gravel and stones that they are rendered unfit for cultivation.

Most of the soil is well drained and deficient in humus. However, it is naturally fertile and easily cultivated on account of its light, open structure. The lower depths are always moist on account of the permanent water table being near the surface. Some few of the sandier portions suffer in times of drought. It is largely farmed in corn, producing an average yield of about 40 bushels. Melons and sweet potatoes do well. The type also furnishes good blue grass pasture.

#### WABASH LOAM.

The surface soil of this type ranges from a light fine sandy loam to a silt loam. The soil is prevailingly black to a depth of 8 to 18 inches. The percentage of very fine sand is high. The soil rarely contains much coarse material. Owing to the predominance of organic matter, the surface is inclined to be loose and sometimes fluffy in the lowest spots.

The depth and character of the subsoil is quite variable. It usually consists of a loam or silt. The subsoil is of a dark color or drab, and mottled with yellow and reddish stains to a depth of 24 to 40 inches. This is mixed with grayish brown, or dark plastic clay or a grayish or bluish and yellow mottled sandy loam or sand. The subsoil is often quite plastic below 20 inches, but the content of sand increases rapidly and the heavier material gives way to a mixture of sand, clay and gravel. The gray sand resembles quicksand. The water table is encountered at about three feet.

The Wabash loam is developed in a few scattering areas along the larger drainage lines. The largest bodies occur along Pine Creek, Secs. 6 and 7, T. 22, R. 8, and along Kickapoo Creek, near its debouchure. It occasionally occupies depressions at the base of the valley slope, or the sites of overflow channels or old bayous, now silted up. The area mentioned no doubt represents an abandoned flood plain of Pine Creek formed when it carried a larger

volume of water than at present. Subsequent agencies, such as erosion, have added much fine material from the surrounding higher lands.

Drainage is the first requirement of this type. A few areas are undrained on account of the small elevation above the stream, and cannot be freed of their excess of water at the present time. The total extent of these undrained areas is very small. With the dredging and widening of the stream channels, now progressing, they will soon be brought under cultivation. Numerous laterals are needed to lower the water table.

The area at Hygania Springs occupies a crater-like basin joining Pine Creek about one-half mile wide. A few peculiar serpentinelike islands—remnants of uplands—rise much above the level of the basin. The area was originally a swamp that was inundated most of the year, but has been reclaimed by drainage and is now under cultivation, and produces large yields of corn. A few areas furnish good pasture. Timothy and alsike clover might be produced profitably on this soil.

#### WABASH SANDY LOAM.

The Wabash sandy loam to a depth a 12 to 20 inches is a very dark brown or black friable sandy loam, or a loamy sand. The content of organic matter is relatively high, and it imparts a mellow or loamy surface.

The subsoil is quite variable, but consists mainly of a brown or grayish brown sandy loam or loam. Frequently the subsoil may be a brown heavy loam to a silty clay loam, even becoming plastic and gummy in the lower portion of the subsoil; but the latter condition is confined to a few small depressed areas. The three-foot section usually contains coarse sand and gravel, and the immediate substratum may be a bed of gravel.

The Wabash sandy loam occurs as a long strip, bordering Pine Creek from near Rainsville to Kramer. The topographic position is essentially developed as a flood plain. But the larger parts of it are no longer flooded and occur as terraces while the remainder is notably above overflow except in extreme high water. Both positions, together with the lower plain, are included with the type.

This soil is very productive and desirable for a number of crops. Its position assures reasonable protection from flood waters. Its good drainage and its large organic matter content provide a high degree of available fertility. Its loose structure renders it easy of cultivation and retentive of moisture.

The Wabash sandy loam in Warren County is well suited to the production of muskmelons and watermelons. It produces a large muskmelon of a rare and delicious flavor. Quite a large acreage of this type is devoted to the production of melons that meet with a ready market. If marketing facilities would permit, more attention could be profitably given to the production of such superior products.

Alfalfa is easily set and does unusually well on the better drained portions. The short overflows are not liable to do much damage except introduction of weed seed. Corn, oats and wheat yield well.

#### ALLIS STONY LOAM.

The Allis stony loam embraces a mixture of soils of local origin, developed on the terrace levels of the Wabash River and Pine Creek. Mansfield sandstone forms the substratum, and has contributed largely to the soil material. It is typically developed in an area extending from Williamsport southwest for about two miles. Three other small bodies are mapped along Pine Creek. It has a low agricultural value.

The surface soil ranges from a gray to black fine sandy loam to loam. The color is usually a brownish gray or light brown in the drained areas. In the swales it is light or dark brown, which may extend to a depth of 20 inches or more. The content of organic matter is typically low, and below six to eight inches the soil becomes a light yellow or bright gray sand. In the poorly drained spots the subsoil is a drab or dark colored silty clay, highly mottled with red and yellow blotches. In these places the bed rock is encountered at greater depth, or not at all in the three-foot section.

The surface portion carries a high percentage of angular fragments of a yellowish brown medium grained sandstone, known geologically as Mansfield. It belongs to the Pennsylvanian system of rocks that forms the base of the Coal Measures. A massive outcrop of this formation may be seen at Williamsport where Fall Creek has cut out a ravine over 60 feet in depth in this rock.

The bits of sandstone strewn over the surface are highly ferruginous and have resisted decay. The bodies along Pine Creek are not very stony at the surface, but are underlain at no great depth with bed rock, and so were included in this type.

The area below Williamsport appears to be the remnant of a former terrace. It lies about 8 to 10 feet above the flood plain and from 15 to 20 feet below the adjoining terrace. Material is



mostly residual. The former covering of alluvium has doubtless been removed by stream action or erosion.

The surface is uneven, being intermittently wet and dry. The depressions are filled with buttonwood and willows. The drained parts are forested with white oak. The type has no other value than for the pasture it affords.

#### MEADOW.

The first bottom or overflow land along the minor streams and a few areas through the wider bottoms in the county are termed meadow on account of the mixed nature of the soil and the poor drainage conditions. The area of different soil types was so small that it would be next to impossible to separate them. Moreover the alluvium is subject to regular changes by floods so that a given classification might change at any time. The predominating type is a mixed loam of a dark brown or black color. The material varies from a silt loam or silty clay loam, to sandy loam. The heavier and darker areas are to be found in the flat portions, while the wavy or gently undulating areas are lighter in color, and loamier.

The subsoil is mostly mottled drab or brown and grayish loam to silty clay loam, somewhat heavier than the soil. Usually there is no line of separation between the soil and subsoil, the only difference being a perceptibly lighter color in the subsoil.

Frequently the lower subsoil and the underlying substratum is a gray sand or reddish gravel. The gravel is found mostly along the prairie streams.

Most of the alluvial material is of recent origin. Many of the valleys are shallow, narrow, flat, and poorly defined. The blufflike bank that is usually present on either side of the stream is gradually lost up stream, and the distinction between meadow and the Clyde silty clay loam is arbitrary. In the central part of the county and in the area fronting the Wabash, the streams have cut deep and tortuous courses in an effort to reach the creeks, and formed narrow flood plains. Sometimes at the base of the declivities there is a large accumulation of material that resembles the uplands in color and texture. This represents an accumulation of sediment washed down from above. Some of the valleys are walled in by perpendicular bluffs of sandstone and shale and these have influenced the soils a little either by disintegration or by contributing fragments to the surface.

Most of land classed as meadow is not suitable for cultivation on account of poor drainage and frequent overflow, but does furnish

good blue grass pasture. Some areas are under cultivation but these are largely sandy spots. Corn is the chief crop on such areas and excellent yields are oftentimes secured.

A few irregular areas on the Wabash bottoms that are covered with water for several weeks in the spring, or permanently wet, were mapped as meadow. The soil is a heavy silt loam with a grayish silt loam or silty clay loam subsoil. Such bodies are covered with a dense growth of silver maple and elm.

The actual width of the strips of alluvium or meadow is in most places exaggerated on the map. The position of the stream in such areas is only approximate. The tracts of meadow bordered by the Shelby silt loam are usually of low agricultural value.

#### MUCK.

The classification Muck includes the soil composed largely or almost entirely of organic matter. It has been formed by the accumulation of the remains of various plants, spagnum moss being the principal species. These deposits occurred either under water or in a condition of constant saturation. The first stage of formation is usually peat, in which the vegetable remains are still noticeable, but further advancement gives a very black, powdery organic material with a characteristic greasy feel when moist with the mass of organic materials mixed with varying amounts of mineral matter washed in from the surrounding higher lands. It varies in depth from only a few inches on the margin to more than three feet in the center. There is but little change in color with depth, but in the lower sections the vegetable fibres become more noticeable. The muck rests upon bluish black, stiff plastic clay which grades into a lighter colored or grayish mottled clay. The subsoil is highly streaked with iron stains. Some areas are underlain with coarse sand and less frequently an impure marl. The water table is encountered at less than three feet.

The smaller areas of muck indicated on the map are usually but a few inches deep, and generally have enough soil material mixed with it to give rise to a loam type. In other spots where the muck is in an advanced stage of decomposition it consists of a loose, chaffy surface and might also be classed as a loam. A small area of peat in Sec. 2, T. 20 and 21, R. 7, was included with the muck type.

The muck areas occur in the shallow basins or depressions which at a former time were lakes and ponds, gradually being filled with remains of aquatic vegetation. The largest area is located in the northeastern part of the county and covers about one section of

land. Not much of the body is under cultivation at present, owing to its inadequate drainage. A drainage way was formerly established, but the settling of the muck after cultivation destroyed the power of the ditch. The area was resurveyed this year and the ditches will be lowered and drainage re-established. A few small patches occur as isolated patches in the prairie; most of these are under cultivation.

Large yields of corn, oats, timothy and alsike clover are secured in dry years. The greatest problem in handling muck is establishing good drainage, either by removing the surface water or lowering the water table. Another troublesome factor is the early and late frost. The use of a heavy roller to firm the seed bed is very effective in preventing damage by late frosts.

Muck soils have shown marked response to the use of potassium fertilizers. Coarse barnyard manure and lime are also to be recommended.

#### BOULDER AREAS.

Boulder areas embrace a few areas of limited extent on the terraces near Independence. The most typical area occurs in Sec. 23, T. 22, R. 7. The surface is so thickly covered with granite boulders that will average less than three feet in diameter as to be unfit for cultivation, and perhaps so numerous that the expense of removing them would be prohibitive. The soil occupied by these boulders is the Fox silt loam.

They were doubtless transported by the glacier to the position where they now rest, as the terrace seems to be one of planation.

The boulder areas afford fair pasture land.

Boulders are more numerous on the opposite side of the river at a similar elevation.

#### SUMMARY.

Warren County is situated on the western boundary of Indiana, north of the center of the State. It has an approximate area of 364 square miles or 232,960 acres.

The topography varies from level to undulating, becoming broken along the area fronting the Wabash River, and in a belt extending along the course of Pine Creek. The timbered or gray lands reach back from the river to an average distance of five miles. The average elevation above sea level is about 700 feet.

The drainage is made simple by the Wabash River on the east. All the principal tributaries flow southeastward to join the Wabash.

Artificial drainage has reclaimed all the former waterlogged areas of the prairie.

The first active settlement in the county was made in 1824. The county was organized in 1827. Williamsport is the chief town and county seat, and has a population of about 1,200.

The transportation facilities are ample. Six railroads cross the county. The county has a total of 336 miles of improved public roads.

The population of the county, according to the last census, is 10,899. It is wholly rural, and the occupations are entirely agricultural. The improvements are of the best type, and the inhabitants are enjoying prosperity, which is due largely to the fertile soils.

The climate is similar to that of the general region, which is characterized by wide variations. The average rainfall is 38 inches. The length of the average growing season is about five and one-half months.

The cultural methods and practices apply solely to grain farming. Corn and oats are grown almost exclusively on the prairie soils. More wheat and clover are grown on the gray or "clay" soils. Corn will average about 40 bushels per acre; oats, 30 bushels; wheat, 15 bushels. Clover failures have been quite general in past five years.

The general plan suggested for improving most of the soil types is better drainage, and to grow more leguminous crops in suitable rotation, with the aid of ground limestone and acid or rock phosphate, and to maintain more live stock.

Warren County is an area of large holdings. The average size farm is 161.4 acres. A complex system of tenantry prevails, 41.6 per cent. of farmers being renters; perhaps three-fourths of the prairie farms are rented.

Hog raising is the principal live stock industry. No attention is given dairying, and comparatively few cattle are fed.

The soils are derived largely from the unconsolidated deposits of the early Wisconsin glaciation. The main soil forming material is a silty or loess-like layer averaging 30 inches in thickness. The alluvial soils are quite extensive. Fifteen (15) types and three phases have been mapped and described.

The Carrington silt loam is the most extensive and important soil. It embraces the undulating prairie soils that are naturally well surface drained, and are brown in color. The phosphorus and lime supply of the soil is known to be low.

The Clyde silty clay loam represents the lower lying, heavier soils of the flat prairie. The type was formed under swampy conditions. Under artificial drainage it is a strong corn and oat soil.

The Miami silt loam occupies the timbered or gray colored lands. The surface ranges from undulating to rolling. It is best adapted to wheat and grass. The nitrogen, phosphorus and lime content is low. A small area of this soil has a level or flat topography and was separated as the flat phase.

Bordering the streams there is a zone of badly eroded or hilly land that was mapped as Shelby silt loam. This soil has a low agricultural value and cannot be used for ordinary cropping purposes satisfactorily.

The Fox silt loam includes most of the soils on the high terraces along the Wabash River. It consists of about 18 inches of a brown silty loam, overlying a massive bed of gravel. Only early maturing crops should ever be grown and more live stock kept as a medium for marketing the crops and to insure an income in unfavorable years. The gravelly phase has a shallower soil.

The Fox sandy loam and gravelly sandy loam are similar soils of small extent. They are inclined to be droughty.

The Sioux coarse sandy loam is a black colored terrace soil which was developed under prairie conditions. Corn, oats and wheat are grown, with varying success.

The Allis stony loam is a derivative soil on the terraces, of little agricultural value.

The Genesee silt loam embraces most of the alluvium or first bottom lands. Corn is the only crop grown and yields high. The sandy loam member is an associated type of limited area.

The Wabash sandy loam and loam occur as first bottoms along Pine and Kickapoo Creeks. The soil is dark brown or black in color, and very productive when well drained. Corn does well on the loam type while the sandy loam produces a superior product of muskmelons and watermelons.

Meadow includes the narrow strips of alluvial land along the minor drainage ways, and in a few areas through the wider bottoms. The soil is a mixed brown loam, generally poorly drained.

Muck is an organic soil. The boulder areas embrace a few small fields of stony land.

Warren County soils are still comparatively fertile and crops produced in favorable years are yet large, but sufficient evidence is at hand to show that profitable yields of certain crops are not being



produced either because of the deficiency of certain necessary elements or because of the lack of proper physical conditions. As a whole the soils are among the most fertile in the State, but the methods of farming are the most destructive. The farmers of the prairie have relied too much on their rich soils and have been backward in realizing the benefits and possibilities of scientific methods. The present practices seem to be leading headlong into ruin. Maximum crops may be obtained indefinitely if proper methods are instituted at once.